

CRASH DATA RESEARCH CENTER

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CALSPAN ON-SITE AMBULANCE CRASH INVESTIGATION

SCI CASE NO: CA09082

VEHICLE: 2004 FREIGHTLINER 2500 SHC / MEDIX TYPE II AMBULANCE

LOCATION: TENNESSEE

CRASH DATE: OCTOBER 2009

Contract No. DTNH22-07-C-00043

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points are coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

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BACKGROUND

This on-site investigation focused on the severity of the crash and source of injury to the occupants of a 2004 Freightliner 2500 SHC cargo van converted into a Type II ambulance by Medix Specialty Vehicles, Incorporated (**Figure 1**). The Freightliner was involved in a left side impact crash with a 2006 Dodge Ram 1500 series pickup truck with a subsequent rollover. The one-quarter turn rollover event was interrupted as the top rear aspect of the Freightliner struck a non-breakaway utility pole as it slid on its right side. The crash resulted in the death of a 78-year-old female patient. All other occupants were injured in the crash, including a 25-year-old male Emergency Medical Technician (EMT) driver of the ambulance, a 20-year-old male EMT passenger in the patient compartment of the ambulance, and the 57-year-old male driver of the Dodge.



Figure 1: Involved ambulance.
(Image courtesy of the ambulance company)

The State Director of Emergency Medical Services (EMS) provided notification of this crash to the National Highway Traffic Safety Administration (NHTSA). Details of the crash were forwarded to the Calspan Special Crash Investigations (SCI) team on November 23, 2009 for follow-up. The SCI team located the ambulance at a local insurance salvage facility and established cooperation with the Regional EMS Coordinator and the insurance carrier to inspect the vehicle. The on-site investigation took place on January 19-20, 2010 and involved the thorough inspection and documentation of the damage to the ambulance, occupant positions, restraint availability, injury sources, and interior configuration. In addition, the crash site was documented and interviews were conducted with ambulance company management and the patient compartment EMT. The driver of the ambulance declined an interview for legal reasons. The Dodge was sold at auction prior to this on-site investigation and was not inspected. Images of the Dodge were obtained from the ambulance company.

SUMMARY

Crash Site

This crash occurred at a controlled four-leg intersection during nighttime hours. Overhead lights and ambient light from commercial lots illuminated the intersection. Weather conditions at the time of the crash consisted of scattered clouds with a temperature of 26 degrees Celsius (78 Fahrenheit) and southerly winds of 16 km/h (10 mph). The source of the weather data was WeatherUnderground (wunderground.com), an online weather data service. The Freightliner ambulance was northbound in the



Figure 2: Northbound trajectory view of the crash site.

3.1 m (10 ft) wide outboard travel lane of a straight and level, undivided, two-way, seven-lane roadway. The east and west legs of the intersection consisted of an undivided, seven-lane roadway. The center lane in all directions was a dual direction left-turn lane, with inboard double-solid yellow centerlines and outboard single-solid white delineation lines. Concrete barrier curbs bordered the outboard travel lanes in all directions. Both roadways were surfaces with asphalt. The posted speed limit in all directions was 64 km/h (40 mph).

The Freightliner struck a wooden utility pole that was located 0.8 m (3 ft) east, and 8 m (26 ft) north of the northeast quadrant of the intersection. **Figure 2** is a northbound trajectory view approaching the intersection. A schematic of the crash is included as **Figure 15**.

Vehicle Data

2004 Freightliner 2500 SHC

The ambulance chassis was a 2004 Freightliner 2500 SHC cargo van, depicted in **Figure 3**. The vehicle was manufactured in September 2004 and was identified by the Vehicle Identification Number (VIN): WD2PD644545 (production sequence deleted). The digital odometer reading at the time of SCI inspection was 278,814 km (173,247 miles). The Freightliner was manufactured as a complete vehicle with a two-door cab, two center closing rear doors, and a right side sliding door.



Figure 3: Front left oblique view of the 2004 Freightliner ambulance.

The Freightliner had a 356 cm (140 in) wheelbase and was 563 cm (222 in) in overall length. The powertrain for this rear-wheel drive platform consisted of a Mercedes-Benz 2.7-liter inline 5-cylinder diesel engine linked to a 5-speed automatic transmission. The service brakes were hydraulic 4-wheel, power-assisted disc with anti-lock. The manufacturer's recommended tire size was 225/75R16 front and rear with cold tire pressures of 379 kPa (55 PSI) and 552 kPa (80 PSI), respectively. At the time of the crash, the Freightliner was equipped with Toyo H/T Open Country radial tires of the recommended size, mounted on OEM steel wheels. The specific tire data at the time of the SCI inspection was as follows:

Position	Tire Identification Number	Measured Tire Pressure	Measured Tread Depth	Tire and Wheel Damage
LF	9TAK D2K 1108	410 kPa (59 PSI)	6 mm (8/32")	None
RF	9TAK D2K 5207	407 kPa (59 PSI)	6 mm (8/32")	Wheel abraded
LR	9TAK D2K 1108	393 kPa (57 PSI)	6 mm (8/32")	Dent to outer bead of wheel with tire sidewall abrasions
RR	9TAK D2K 4907	400 kPa (58 PSI)	4 mm (5/32")	Wheel abraded

The cab of the Freightliner was configured with two box-mounted deluxe high back captain's chairs with adjustable head restraints and manual seat track and recline adjustment features. A folding/adjustable armrest was mounted to the inboard aspect of both seats. The front seating positions were equipped with 3-point lap and shoulder safety belts. The steering wheel featured tilt adjustment, though its position at the time of the crash was unknown. A center console with an array of switches and communications equipment related to the ambulance's emergency response activities was mounted below the instrument panel's stereo and climate controls.

Medix Specialty Vehicles, Inc. Ambulance

The Type II ambulance was manufactured in January 2006 by Medix Specialty Vehicles, Incorporated, and was identified by the Model Number 05-5104. Secondary manufacturing by the aforementioned company consisted of minimal exterior cosmetic modifications and additions. This included the addition of emergency warning lights and auxiliary lighting, which were mounted across the roofline at the front and rear, as well as

at the front and rear aspects of the sides at the roofline. Compartment ventilation ports were located at the upper rear aspect of both sides. A shoreline electric power connection plug was added to the left side, mid level, aft of the B-pillar. **Figure 4** is a back left exterior view of the Freightliner Type II ambulance.

Patient Compartment

The patient compartment of the ambulance was constructed of molded composite interior body panels. The interior incorporated two separate seats, a countertop, Heating Ventilation and Air Conditioning (HVAC) comfort controls, the patient stretcher lights, and numerous storage cabinets and compartments. A stack of storage shelves and lockable compartments was located at the front of the right side, inboard of the forward aspect of the right side sliding door. To the rear of the sliding door was a bench seat above the right rear wheel position with a full-height safety net at its forward edge. The safety net was mounted with two floor tethered buckle anchors and two ceiling tethered latch plate anchors. The bench seat folded upward against the sidewall to accommodate under-seat bulk storage. Lap belts were available to accommodate three passengers on the 180 cm (71 in) long by 30 cm (12 in) wide side-facing bench seat. The right wall served as the seatback for the bench seat. Mounted on the right wall was a polymer biohazard sharp objects trap container. There was also a long storage compartment spanning the roofline overhead of the bench seat. At the rear corner was a vertical storage compartment for the large on-board oxygen tank.

The mid-aspect of the patient compartment was open floor space and the anchor point of the removable wheeled patient stretcher. This area spanned 94 cm (37 in) between the base of the bench seat and the base of the left wall, and had a maximum floor to ceiling height of 184 cm (72.5 in). The parent ambulance company had installed a Stryker Model 6082 MX-Pro-R3 (Serial #020439844) wheeled stretcher with a Ferno floor anchoring system (Serial #L-815518). The



Figure 4: Left rear oblique view of the Freightliner ambulance.



Figure 5: Patient compartment of the involved Type II ambulance.

anchoring system consisted of a forward antler bracket that straddled the wheels and frame at the head of the stretcher, with a rail clamp that secured the rear aspect of the stretcher. When loaded into the ambulance, an anchor pin located on the foot of the stretcher would insert into the rear bracket of the clamp and activate the spring-loaded mechanism, which would lock the stretcher in place for transit. **Figure 5** is an overall image of the interior of the ambulance.

Immediately forward of the stretcher was the rear-facing “Captain’s Chair”. This seating position provided the occupant with a view of the entire patient compartment and access to the patient compartment controls, with close proximity to the driver to enable crew coordination and communication. It also placed the patient’s head area immediately in front of the occupant, with respect to the stretcher, and thus was the best location to manage the patient’s airway during pre-hospital care. The Captain’s Chair seat was adjustable fore and aft with positive stops. A lap belt was available for manual restraint, while a head restraint was integrated into the top of the seatback. To the right of the Captain’s Chair was the center pass-through to the cab, which was equipped with a sliding door that was 141 cm (55.5 in) in height and 46 cm (18 in) wide.

The left side of the patient compartment served for the stowage of EMS supplies required for patient care. A 113 cm (44.5 in) long by 34 cm (13.5 in) deep counter area was located immediately to the left of the Captain’s Chair, with respect to the front of the vehicle. Mounted on the left wall above the countertop were oxygen, suction, and electrical outlets. Below the counter was a 76 cm (30 in) wide by 38 cm (15 in) tall storage compartment. Above the counter was an overhang that served as the control center for the patient compartment, with an array of switches for lighting, a thermostat, electrical power controls, and communications equipment. Within the overhang were the HVAC vents and a 128 cm (50.5 in) long by 18 cm (7 in) tall storage compartment. The remainder of the left wall space consisted of three more large storage compartments with clear sliding doors and a recessed compartment for the stowage of the stair chair.

Ambulance Weight/Payload

The Freightliner was placarded by its manufacturer to have a Gross Vehicle Weight Rating (GVWR) of 3,878 kg (8,550 lb). This was distributed as Gross Axle Weight Ratings (GAWR) of 1,751 kg (3,860 lb) front and 2,431 kg (5,360 lb) rear. The manufacturer of the Medix ambulance had placarded the Type II ambulance with a vehicle weight/payload sticker. This declared that the curb weight of the overall vehicle was 2,862 kg (6,310 lbs). The curb weight at the axle locations was 1,501 kg (3,310 lb) front and 1,334 kg (2,940 lb) rear. The available payload of the vehicle was 1,016 kg (2,240 lb). The estimated weight of the EMS equipment and supplies on-board the ambulance at the time of the crash was 410 kg (900 lb). Accordingly, the ambulance was not overloaded at the time of the crash.

2006 Dodge Ram 1500

The 2006 Dodge Ram 1500 was identified by the Vehicle Identification Number (VIN): 1D7HA18K36J (production sequence deleted). This quad cab pickup truck was rear-wheel drive and was powered by a 3.7-liter, V-6 gasoline engine. The Dodge had a 357 cm (140 in) wheelbase, and was 571 cm (224 in) in overall length. The Dodge was equipped with a redesigned frontal air bag system consisting of a steering wheel hub-mounted driver air bag and a right instrument panel-mounted passenger air bag. The front seats were equipped with 3-point lap and shoulder safety belts for manual restraint with ELR/ALR retractors and pretensioners. The rear safety features are unknown. The Dodge was sold at auction prior to the assignment of this case; therefore, the vehicle was not inspected. **Figure 6** is a front left oblique view of the Dodge the involved Dodge Ram as it was towed from the scene of the crash.

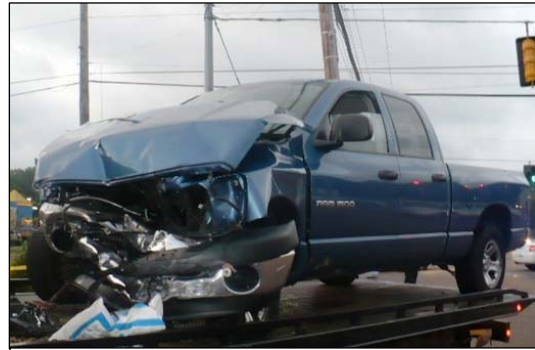


Figure 6: Involved 2006 Dodge Ram pickup truck.

Crash Sequence

Pre-Crash

The two EMTs were nearing the end of their 12-hour shift. Their day thus far had been relatively routine, and had consisted of completing a mechanical check and supply inventory of the ambulance, eating meals, and random relaxation breaks between calls.

The pair had responded to a request for the non-emergent transport of the 78-year-old female patient to a local hospital for a routine medical procedure. En route to the hospital with the patient, responsibilities associated with patient care had led the 20-year-old EMT to be seated unrestrained in the center of the left side-facing bench seat. The patient was positioned semi-Fowler's on the stretcher, and restrained by the lateral leg, lap, and chest straps. Semi-Fowler's is a medical position where the head of the stretcher is elevated between 30 and 45 degrees to optimize comfort and improve breathing in immobile patients.

The ambulance was traveling northbound, approaching a controlled intersection with the emergency lights activated. The ambulance driver reported that the traffic signal turned red as he entered the intersection and that he did not observe any other traffic. The Dodge Ram was traveling westbound, approaching the same intersection. The traffic signal for the Dodge had turned to the green phase. The travel paths of the two vehicles intersected. There was no evidence of avoidance action by either driver at the scene.

Crash

The front of the Dodge impacted the left side of the Freightliner ambulance, aft of the B-pillar. The resultant directions of force were within the 11 o'clock sector for the Freightliner and 2 o'clock for the Dodge. As the two vehicles engaged, the left rear tire of the Freightliner contacted the right corner of the front bumper area of the Dodge. This contact displaced the left rear axle position, lengthening the left wheelbase of the Freightliner. The standard vehicle algorithm of the WinSMASH model was used to calculate the severity of the crash (delta-V) based on an estimated crush profile to the Dodge with lateral end shift. The output serves as a borderline reconstruction due to the use of an estimated crush profile for the Dodge and the default stiffness values utilized for the ambulance. The resulting total delta-V of the Freightliner ambulance was 15 km/h (9.3 mph). The longitudinal and lateral components were -11.5 km/h (-7.1 mph) and 9.6 km/h (6 mph), respectively. The total calculated delta-V of the Dodge was 28 km/h (17.4 mph), with a longitudinal component of -18 km/h (-11.2 mph) and a lateral component of -21.4 km/h (-13.3 mph).

The combination of the wheel engagement and the rearward location of the impact in relation to the vehicle's center of gravity induced a counterclockwise (CCW) rotation to the Freightliner. As the vehicles separated, the Freightliner continued to rotate CCW on the asphalt road surface as it maintained its northbound trajectory. The Freightliner traveled approximately 20 m (66 ft) in a northerly direction and rotated approximately 38 degrees CCW. The rotation, coupled with the vehicle's high center of gravity, resulted in a turn-over rollover event. The vehicle rolled onto its right side as its center of gravity continued in a northerly direction for a distance of 9 m (30 ft). The rollover event was classified "interrupted" as the top right rear corner area of the Freightliner impacted the utility pole. This event arrested the continued CCW rotation of the Freightliner and redirected the vehicle's heading angle to a northerly direction. The Freightliner slid another 35 m (115 ft) on its right side prior to coming to rest at the mouth of a driveway at the east road edge. The total distance traveled from the point of rollover to final rest was approximately 44 m (144 ft). **Figure 7** is an on-scene image to the ambulance at final rest.



Figure 7: On-scene image of the Freightliner ambulance at final rest. (*Local news agency image*)

Following the engagement with the Freightliner, the Dodge rotated in a CCW direction due to the lateral component of the 2 o'clock impact force. It rotated approximately 80 degrees CCW rotation and came to final rest in the middle of the intersection, facing north, approximately 12 m (39 ft) north of the initial point of impact.

Post-Crash

Emergency response to the scene included local police, fire, and EMS. The EMT driver exited the cab of the Freightliner without assistance through the left front door. The EMT in the patient compartment was also exited without assistance through the rear right door. Both EMTs were transported via ground ambulance to local hospitals for treatment of their injuries.

The patient remained restrained on the stretcher by the lateral straps as the ambulance came to rest on its right side. She was removed from the patient compartment of the vehicle by EMS personnel due to her perceived serious injuries. She was transported via ground ambulance to a local trauma center where she admitted to the neurological intensive care unit. She expired approximately 16.5 hours post-crash. The egress of the driver from the Dodge is unknown. He was transported via ground ambulance to a local hospital for the treatment of unknown injuries. Both vehicles were towed from scene.

2004 Freightliner 2500 SHC

Vehicle Damage - Exterior

The left side of the ambulance sustained moderate severity damage from the initial impact event with the Dodge. Maximum crush was 14 cm (5.5 in), located 19 cm (7.5 in) aft of the left C-pillar. The direct contact damage began 150 cm (59 in) aft of the left front axle and extended 259 cm (102 in) to the left taillight location. The combined direct and induced damage (Field L) began 128 cm (50.5 in) aft of the left front axle and extended 329 cm (130 in) to the left taillight. The residual crush measured along the left side at mid-door level was as follows: C1 = 0 cm, C2 = 7 cm (3 in), C3 = 10 cm (4 in), C4 = 11 cm (4.5 in), C5 = 5 cm (2 in) and C6 = 0 cm. The sill height measured 41 cm (16 in). A second profile was documented at the level of the sill At C-locations C4-C6. These values were as follows: C4 = 12 cm (4.5 in), C5 = 6 cm (2.5 in) and C6 = 0 cm. The sill C values at C1 to C3 fell outboard of the sill within and aft of the wheel opening. There was no crush at the door/sill level; therefore, the Door Sill Differential was 0 cm.

The leading edge of the left rear tire of the Freightliner engaged the corner of the Dodge's front bumper. This impact dented the outer bead of the wheel 10 x 1 cm (4 x 0.4 in) and displaced the axle rearward. The left wheelbase was lengthened by 14 cm (5.5 in) to 370 cm (145.5 in). The Collision Deformation Classification (CDC) associated



Figure 8: Left side impact damage to the Freightliner ambulance.

with the side impact event was 11LZEW3. The side impact damage profile is depicted in **Figure 8**.

The direct contact damage from the one-quarter turn rollover event was distributed across the entire right plane of the ambulance, longitudinally and vertically. The damage consisted of surface abrasions with isolated dents to the rear quarter panel area of the vehicle (**Figure 9**). The direct damage began 36 cm (14 in) forward of the right front axle and extended 498 cm (196 in) to the right rear corner. Vertically, the damage began 57 cm (22.5 in) above the ground and extended 204 cm (80.5 in) to the top of the roof panel. The right front door glazing was closed at the time of the crash and was disintegrated by the outside mirror as it was displaced into the glazing during the rollover event. The sliding door glazing was fixed within the frame and was disintegrated during the rollover event. The CDC associated with the one-quarter turn rollover event was 00RDAO3.



Figure 9: Right side rollover damage to the Freightliner ambulance.

The damage from the non-breakaway pole impact event (Event 3) was located at the top rear corner area of the ambulance (**Figure 10**). The direct contact damage was 13 cm (5 in) in width that began at the right rear corner and extending inboard along the back header and the upper aspect of the right rear door. Vertical crush of 6 cm (2.5 in) was located at the center of the direct damage on the back header. The CDC associated with this event was 00TBRN2.



Figure 10: Pole impact damage to the top right corner of the roof of the Freightliner ambulance.

Interior

The ambulance interior was damaged by occupant contact and the displacement of loose objects during the crash sequence. There were no intrusions within the cab of the van-based unit or of the patient compartment. The composite walls of the patient compartment interior concealed minimal intrusion of the side body panels of the vehicle.

The unrestrained driver's left knee impacted and scuffed the knee bolster 66 cm (26 in) left of center and 23 cm (9 in) below the top of the instrument panel. The HVAC vent louver located outboard of the steering column was fractured from probable hand/arm contact by the driver. This vent was located 70-77 cm (27.5-30.5 in) left of center and 1-5 cm (0.5-2 in) below the top of the instrument panel. A bodily fluid stain was located on

the right roof side rail 14-22 cm (5.5-8.5 in) aft of the A-pillar and 0-10 cm (0-4 in) above the right front door at the grab handle. This contact was attributed to the driver's head. There were six distinct areas of contact within the patient compartment. Above the Captain's Chair was an area of deformity to the forward wall. The composite surface was cracked (**Figure 11**) 34-41 cm (13.5-16 in) below the ceiling and 19-24 cm (7.5-9.5 in) left of the vehicle's centerline. This contact was at the upper left corner of the pass-through to the cab area. A 20 cm (8 in) wide by 13 cm (5 in) tall area of scuffing and abrasions was present on the padding above the right sliding access door. There was a 14 cm (5.5 in) wide dent in the right sliding access door, located 76 cm (30 in) above the floor and 19 cm (7.5 in) forward of the C-pillar (**Figure 12**). The rubber gasket at the rear aspect of the right sliding access door was separated from the C-pillar at the beltline. There was a bodily fluid stain on the grab bar mounted on the ceiling in the center of the patient compartment. Remnants of bodily fluid were also present on the right wall above the bench seat.



Figure 11: EMT head impact to the forward wall of the patient compartment.



Figure 12: Right sliding access door contacts within the Freightliner ambulance.

The right rear doors to the patient compartment were dented with green paint transfers surrounding the dents. These were located below the beltline level and were attributed to the contact by the portable oxygen cylinders.

Manual Safety Belt Systems

The Freightliner was equipped with manual 3-point lap and shoulder safety belts for both front occupant positions. The driver's belt was equipped with a sliding latch plate, an Emergency Locking Retractor (ELR), and a retractor pretensioner. The front right belt system was equipped with a sliding latch plate, a switchable ELR/Automatic Locking Retractor (ALR), and a retractor pretensioner. At the time of SCI inspection, the driver's safety belt was taut in its stowed position against the B-pillar as the retractor pretensioner had actuated during the crash (**Figure 13**). Furthermore, a lack of loading evidence on the latch plate, D-ring, or belt webbing supported the SCI conclusion that the driver was

not restrained by the manual safety belt at the time of the crash. The front right seat was unoccupied, however, the retractor pretensioner actuated, cinching the belt webbing taut against the pillar.

All seats in the patient compartment were equipped with manual lap belts. The Captain's Chair lap belt was mounted on the box-mount. The right side bench seat was equipped with three lap belts, anchored on the right wall. None of these belt systems was utilized at the time of the crash.

The patient stretcher was equipped with straps positioned at the chest, lap, and leg locations of the patient. The ambulance company representative reported to the SCI team that at the time of the crash, the patient was restrained by the lateral leg, lap, and chest straps. This reinforced the post-crash emergency response personnel's findings of the patient still positioned on the stretcher. However, the straps had been removed from the stretcher prior to the SCI investigation, and were not available for inspection.

Air Bag System

The Freightliner was equipped with a redesigned frontal air bag system that consisted of a steering wheel hub-mounted driver air bag and a mid right instrument panel-mounted front right passenger air bag. Both of these air bags deployed as a result of the crash.

The steering wheel hub-mounted driver air bag pictured in **Figure 14** was identified by the manufacturer's code 449406832601. It was constructed of Automotive Safety Components International (ASCI) recognized PA 6.6 nylon material. The driver air bag had properly deployed through its three designated flaps in the face of the 4-spoke steering wheel, without damage. The air bag was 62 cm (24.5 in) in diameter in its deflated stated and was not tethered or vented. Maximum rearward excursion from the center hub measured 53 cm (21 in). There was no evidence of occupant contact found on the bag at the time of SCI inspection.

The front right passenger air bag was identified by the manufacturer's code 17804057529 and labeled at the 6-o'clock aspect with TSR211LH0011. The air bag had properly deployed through its 34 x 13 cm (13.5 x 5 in) cover flap, which was tethered

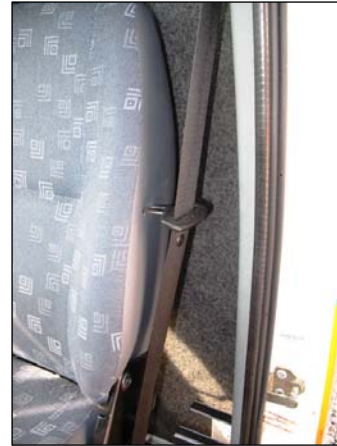


Figure 13: Taut driver safety belt.



Figure 14: Deployed driver air bag in the Freightliner ambulance.

on either end by 8 cm (3 in) tethers. The air bag was 56 cm (22 in) wide and 46 cm (18 in) tall, and had a lower extension that was 41 cm (16 in) wide by 51 cm (20 in) tall. There was no contact evidence found on the front right passenger air bag.

Occupant Data

Driver Demographics

Age / Sex:	25-year-old / Male
Height:	180 cm (71 in)
Weight:	70 kg (155 lb)
Seat Track Position:	Unknown
Safety Belt Usage:	None, unrestrained
Usage Source:	SCI vehicle inspection
Eyewear:	None
Egress from Vehicle:	Exited without assistance
Type of Medical Treatment:	Transported by ground ambulance to a local hospital where he was treated for his injuries and released

Driver Injuries

Injury	Injury Severity (AIS90/Update 98)	Injury Source
Scalp laceration, sutured NFS	Minor (190600.1,9)	Grab handle on right roof side rail
Left lateral thigh contusion	Minor (890402.1,2)	Left door armrest in rear upper quadrant

Source – Interview from Ambulance Company.

Driver Kinematics

The driver of the ambulance was seated unrestrained in an unknown track position. He was dressed in a short-sleeve polo shirt and khaki pants. The driver was not restrained by the manual safety belt system. The lack of belt usage was determined from the taut position of the belt system against the B-pillar resulting from the actuation of the retractor pretensioner.

At impact with the Dodge, the driver responded to the side impact event by initiating a forward and left lateral trajectory. His left lateral thigh contacted the door panel as his left knee contacted the knee bolster. There was no contact evidence to the door panel; however, the storage tray at the left edge of the bolster panel was scuffed. The driver sustained a contusion of the left lateral thigh from his contact with the door panel. His left hand separated from the steering wheel and contacted the HVAC vent located in the upper left corner of the instrument panel. There was no injury associated with this event.

As the ambulance initiated the rollover sequence to the right, the driver moved laterally across the interior of the vehicle. His torso probably loaded the deployed air bags. His head impacted the right roof side rail and grab handle. This contact produced a laceration of his scalp. Body fluid was present of the grab handle and the surrounding area. As the vehicle slid to rest on its right side, the driver came to rest on the right roof side rail, right door, and roadway exposed by the disintegrated right front glazing.

The driver reached upward and opened the left front door post-crash. He exited the vehicle without assistance. Body fluid was present on the area of the left B-pillar; on the door frame and external to the passenger compartment. The driver was transported from the scene by EMS ground ambulance to the local hospital where he was treated for his injuries and released. The treatment included suturing of the scalp laceration.

Bench Seat Passenger Demographics

Age / Sex:	20-year-old / Male
Height:	180 cm (71 in)
Weight:	64 kg (140 lb)
Seat Track Position:	Fixed
Safety Belt Usage:	Unrestrained
Usage Source:	SCI vehicle inspection
Egress from Vehicle:	Exited vehicle without assistance through back right door
Type of Medical Treatment:	Transported by ground ambulance to a local hospital where he was admitted overnight for treatment and observation.

Bench Seat Passenger Injuries

Injury	Injury Severity (AIS90/Update 98)	Injury Source
Fractured right clavicle	Moderate (752200.2,1)	Padded right roof side rail area above sliding door
Fractured right index finger	Minor (752404.1,1)	Unknown
Large abrasion over right hip, NFS	Minor (890202.1,1)	Road surface
Sutured laceration of the superior/occipital scalp	Minor (190600.1,6)	Forward wall of the patient compartment

Source - Interview from Ambulance Company.

Bench Seat Passenger Kinematics

The bench seat passenger was seated unrestrained in the center of the left side-facing bench seat on the right side of the patient compartment. The passenger responded to the

initial left side impact by moving laterally to his right and forward with respect to his seating position. Due to his unrestrained status, the passenger was displaced from the bench seat and traveled across the interior of the patient compartment. His lower extremities probably contacted the cot and/or the patient. During this trajectory, the ambulance rotated CCW direction by the crash. The passenger moved left and forward with respect to the interior and impacted the stack of compartments and the Captain's Chair at the forward left quadrant of the patient compartment. His head impacted the rigid wall above the Captain's Chair. The composite wall was fractured adjacent to the foam padding. This contact resulted in the laceration of his occipital scalp.

As the ambulance initiated the rollover sequence and impacted the pole, the bench seat passenger was redirected to the right of the patient compartment. His right hip impacted the mid area of the right sliding door immediately below the glazing. This contact produced the large dent to the door. The glazing disintegrated as the vehicle impacted the road surface and slid on its right side to final rest. The passenger's right hip traveled through the glazing opening and contacted the pavement. As a result of the contact with the road surface and the continued movement of the ambulance, the passenger sustained a large abrasion of the right hip area from pavement contact.

The passenger's right shoulder probably contacted the padded area above the right side sliding door. This padded surface was scuffed and abraded. He sustained a right clavicle fracture that was probably attributed to this contact.

During the crash events, the passenger was in contact with internal loose objects. These objects were removed from the ambulance prior to the SCI inspection. The source of the right index finger fracture could not be identified.

The bench seat occupant exited the patient compartment through the rear right door without assistance. He was transported by EMS ground ambulance to the local hospital, where he was hospitalized overnight for treatment of his injuries.

Patient Demographics

Age / Sex: 78-year-old / Female
Height: 168 cm (66 in)
Weight: 68 kg (150 lb)
Position: Semi-Fowler's, rear-facing
Safety Belt Usage: Restrained by leg, lap, and torso straps
Usage Source: SCI vehicle inspection, EMT interviews
Egress from Vehicle: Removed by EMS personnel
Type of Medical Treatment: Transported by ground ambulance to a local hospital where she expired approximately 16.5 hours following the crash.

Patient Injuries

Injury	Injury Severity (AIS 90/Update 98)	Injury Source
Multiple blunt force injuries with head trauma, NFS	Unknown (115999.7,0)	Multiple unknown sources

Source – Medical Examiner's Report, no autopsy

Patient Kinematics

The patient was positioned semi-Fowler's on the rear-facing stretcher, restrained by the lateral leg, lap, and chest straps. She responded to the vehicle's left side impact event by initiating a forward and right lateral trajectory with respect to her rear-facing orientation. She probably contacted the side rail of the stretcher with her right side, and remained in contact with the stretcher due to the utilization of the lateral manual restraint straps. The unrestrained EMT probably contacted the patient as he moved across the interior of the patient compartment.

As the vehicle initiated its rollover sequence, the patient loaded the safety straps. She remained in contact with the stretcher throughout the rollover sequence, and was still restrained by the three lateral straps when the vehicle came to final rest. During the crash events, the patient probably sustained contact from internal loose objects. These objects included the portable oxygen bottles, medical equipment, and the cardiac monitor.

Post-crash, the patient was conscious and in contact with the stretcher. The stretcher remained locked into the floor anchoring system during the crash sequence. She was removed from the patient compartment of the ambulance by EMS personnel and was transported to a local trauma center where she remained conscious for approximately two hours. The patient was admitted to the neurological intensive care unit with head trauma. She went into cardiac arrest and succumbed to her injuries approximately 16.5 hours post-crash. The hospital would not release the patient's records and the family declined

an autopsy. The Medical Examiner's Report listed the cause of death as multiple blunt force trauma.

2006 Dodge Ram

Exterior Damage

Based on the on-scene photographs provided by the parent ambulance company, such as **Figure 14**, the front end of the Dodge sustained disabling damage from the crash. There was longitudinal crush to the bumper, grille, hood, and fender, and both headlight assemblies were disintegrated. There was significant damage to under hood components as well, as the radiator and fluid reservoirs were crushed rearward. There also appeared to be left lateral shift of front end



Figure 14: Damage sustained by the Dodge.
(Image courtesy of the ambulance company)

components, including the bumper and both fenders. Direct contact damage extended from bumper corner to bumper corner. Maximum crush to the front of the Dodge was near the center, biased to the right side. For reconstruction purposes, a crush profile was estimated based on SCI experience and available photographs. The corresponding estimated crush profile was as follows: C1 = 12 cm (5 in) , C2 = 18 cm (7 in), C3 = 33 cm (10 in), C4 = 45 cm (13 in), C5 = 30 cm (12 in) and C6 = 25 cm (10 in). Noting vehicle end shift based on visible damage and impact configuration, the CDC associated with the impact event was 82FDEW2.

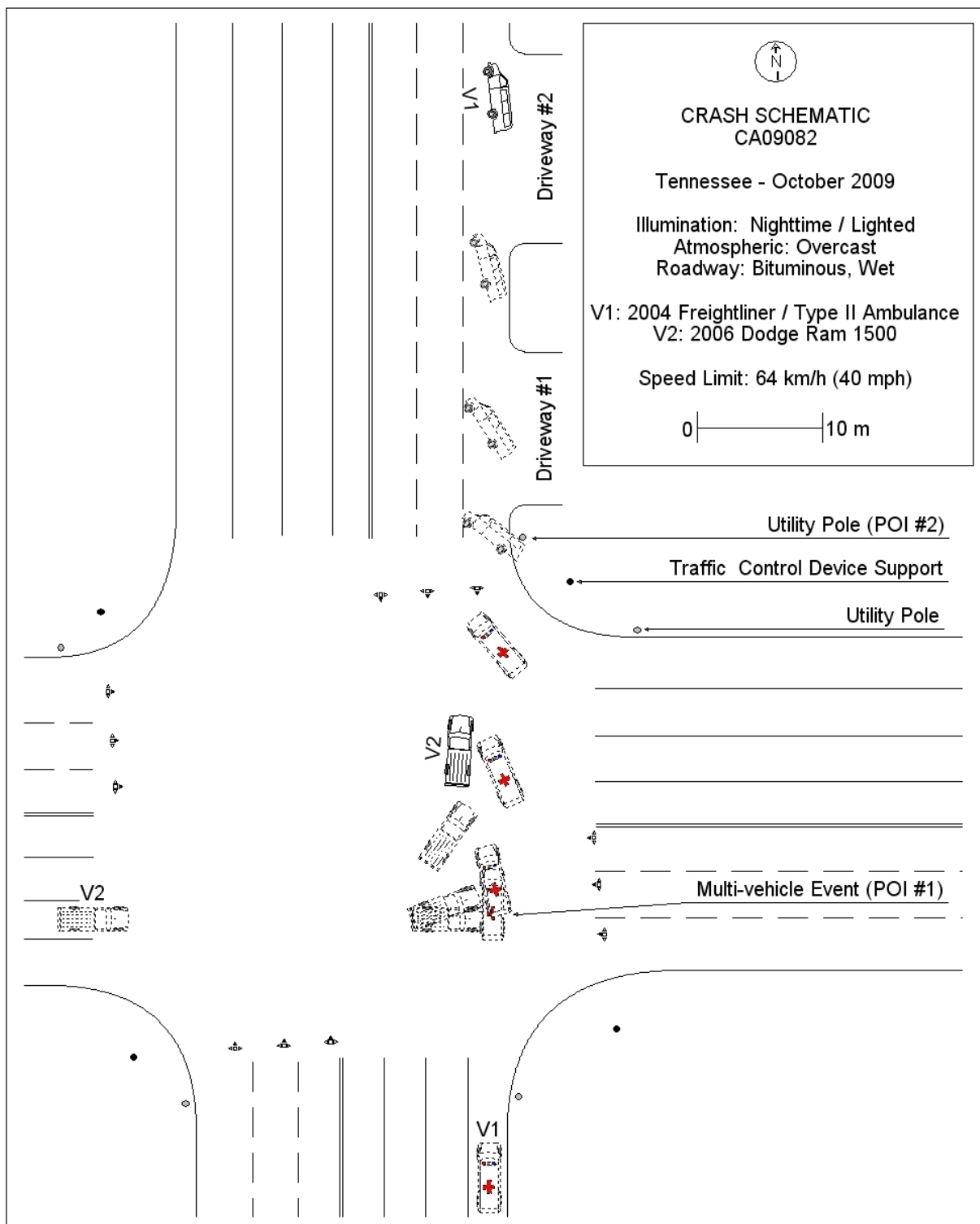


Figure 15: Crash Schematic.